



AT 1/724/10

Attorney's Docket No. 1217-010754

TRANSMITTAL LETTER

Commissioner for Patents  
Washington, D.C. 20231

Serial No.: 09/854,807  
Examiner: Ivars C. Cintins  
Invention: "Method of Regenerating Ion Exchange Resin"

Filing Date: May 14, 2001  
Group Art Unit: 1724

RECEIVED  
DEC 30 2002  
TC 1700

Transmitted herewith is an Amendment in the above-identified application.

- ☒ Small Entity Status has been asserted for this application under 37 CFR 1.27.  
☐ A verified statement to establish small entity status under 37 CFR 1.27 is enclosed.  
☒ No additional fee is required.  
☐ The fee has been calculated as shown below:

No of Claims After Amendment	Highest No. Previously Paid For	Present Extra	Small Entity Rate	Non-Small Entity Rate	Charge
Total 4	20	0	x \$ 9.00	x \$ 18.00	\$ 0
Indep. 1	3	0	x \$ 42.00	x \$ 84.00	\$ 0
First Presentation of Multiple Dependent Claim/s			+ \$140.00	+ \$280.00	\$ 0
TOTAL ADDITIONAL FEE					\$ 0

- ☐ A check in the amount of \$\_\_\_\_\_ is enclosed to cover the filing fee.  
☒ A check in the amount of \$ 55.00 is enclosed for a one- month Petition for Extension of Time.  
☒ The Commissioner is hereby authorized to charge payment of the following fees associated with this communication to Deposit Account No. 23-0650. Please refund any overpayment to Deposit Account No. 23-0650. An original and two copies of this sheet are enclosed.  
☒ Any additional filing fees required under 37 CFR 1.16.  
☒ Any patent application processing fees under 37 CFR 1.17.

December 19, 2002  
Date

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Diane Paull  
(Name of Person Mailing Paper)

*Diane Paull*  
Signature

12/19/2002  
Date



7  
TW  
1-2-03  
Response Under 37 CFR 1.116  
Expedited Procedure  
Examining Group 1724  
PATENT APPLICATION  
Serial No. 09/854,807  
Atty. Docket No. 1217-010754

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Group Art Unit 1724 :  
In re application of :  
FUJIO TANAKA ET AL. : METHOD OF REGENERATING  
Serial No. 09/854,807 : ION EXCHANGE RESIN  
Filed May 14, 2001 :  
Examiner - Ivars C. Cintins :

Pittsburgh, Pennsylvania  
December 19, 2002

RECEIVED  
DEC 30 2002  
TC 1700

**RESPONSE AFTER FINAL REJECTION**

**Box AF**  
Commissioner for Patents  
Washington, D.C. 20231

Sir:

In response to the Final Office Action dated August 27, 2002, Applicants  
hereby submit a Petition for One-Month Extension of Time and the following remarks.

**REMARKS**

Claims 1-4 are pending in the present application.

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20231 on December 19, 2002.

**Diane Paull**

(Name of Person Mailing Paper)

*Diane Paull*  
Signature

12/19/2002  
Date

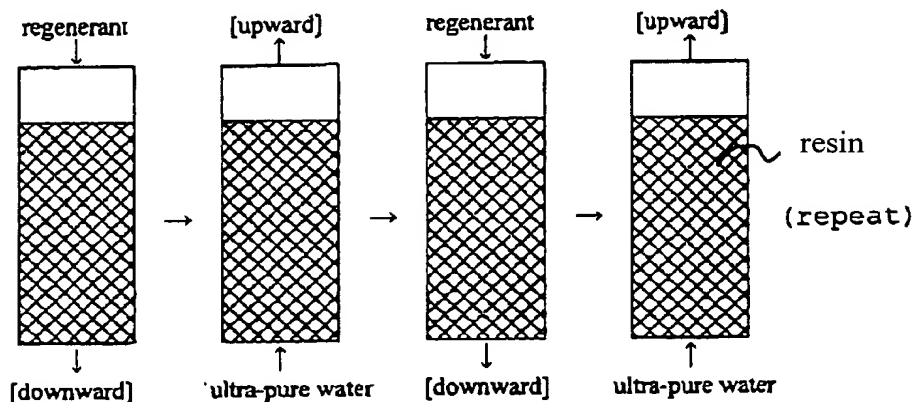
The present invention is directed to a method of regenerating an ion exchange resin. The method includes the steps of packing a used ion exchange resin in a regeneration tower and repeating, at least twice, a step that includes passing an aqueous solution of regenerant through the regeneration tower downward from a top part of the regeneration tower and thereafter passing ultra-pure water through the regeneration tower upward from the bottom of the regeneration tower.

Claims 1 and 2 stand rejected under 35 U.S.C. § 103(a) as being obvious over U.S. Patent No. 3,711,401 to Hamilton et al. (hereinafter "the Hamilton patent") in view of U.S. Patent No. 6,340,712 to Kunin et al. (hereinafter "the Kunin patent"). The Examiner maintains that it would have been obvious to one skilled in the art to subject the ion exchange resin based on the combination of the Hamilton patent and the Kunin patent to multiple regeneration and washing steps in order to ensure that the resins are adequately regenerated and washed. Applicants respectfully disagree.

The Hamilton patent discloses a regeneration method for dual bed ion exchange resins. The operation disclosed in the Hamilton patent is a rinsing (washing) operation of the ion exchange resin designed to remove any remaining regenerant. "Backwashing" is carried out, in the Hamilton method, to separate the weak resins and strong resins based on differences in their specific gravity or density.

The Kunin patent discloses a non-chloride containing regenerant composition and method for regenerating water softeners. The Kunin method does not include the repeated downward application of an aqueous solution of regenerant solution and an upward application of ultra-pure water as in the presently claimed invention.

The regeneration tower of the present invention may be depicted as follows:



The regenerant is one or the other of an acid or base compound appropriate to the ion exchange resin used in the present invention. In the operation of the ion exchange resin as described above, channeling of the regenerant as it passes through the ion exchange resin is generally avoided. Even if channeling occurs in a layer of the ion exchange resin, the channeling effect is broken, preventing the occurrence of nonuniform regeneration. This allows the ion exchange resin to be regenerated efficiently and homogeneously.

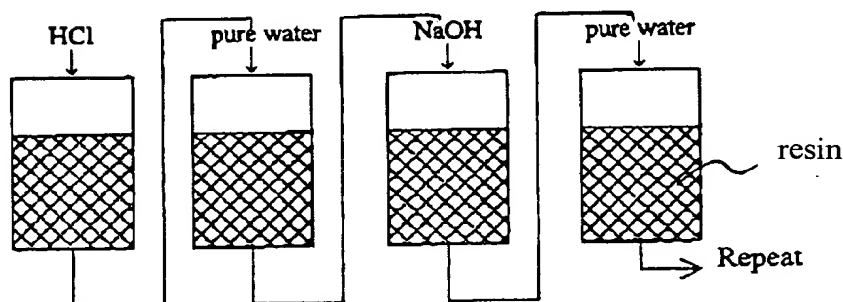
Additionally, in the present invention, the regeneration of the ion exchange resin is carried out through the use of an ion exchange resin tower (regeneration tower), which is different from the purifier towers in the methods disclosed in the cited prior art. In the present method, mixing of the regenerant into the purifier towers can be avoided. Thus, in the present invention, there is no need to interrupt the purification of an aqueous hydrogen peroxide solution.

It is known that the spent ion exchange resin is generally regenerated by a regenerant. For example, an anion exchange resin is typically regenerated by packing the anion exchange resin in a tower and, once or more, sequentially passing an alkali aqueous solution and an acid aqueous solution through the anion exchange resin tower.

This process is reviewed in detail in the Japanese language publication "Analytic Chemistry Handbook" published by Asakura Shoten. A copy of the relevant portions of this publication and an English language translation thereof are attached hereto. The publication describes the operation of a basic ion exchange column, which may be summarized as follows:

- 1) The spent ion exchange resin is packed in a column;
- 2) The ion exchange resin is adequately washed by pure water (sometimes by backwashing);
- 3) HCl solution is passed through the washed resin in the column;
- 4) The HCl treated resin is washed by pure water;
- 5) NaOH solution is passed through the washed resin in the column to change the functional group of the ion-exchange resin to  $\text{Na}^+$  or  $\text{OH}^-$  form;
- 6) The NaOH treated resin is washed using pure water; and
- 7) Steps 3) to 6) are repeated several times (typically, two or three times).

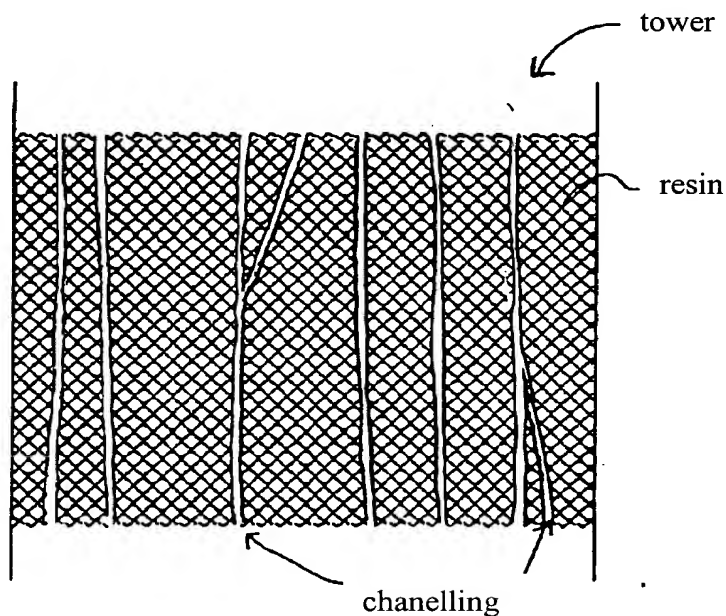
The process is shown in the schematic diagram below:



For resins regenerated by the method described above, a regenerant, such as NaOH or HCl, may remain in the ion exchange resin. This residual may act to prevent or retard the removal of ionic impurities from an aqueous hydrogen peroxide solution. The regeneration method described above is generally followed in the methods described in the Hamilton patent and the Kunin patent.

Further, in this conventional method, channels are formed ("channeling") through which much of the regenerant passes. Channeling leads to non-uniform contact between the regenerant and the ion exchange resin, which results in an ion exchange resin that is not homogeneously regenerated.

Channeling occurs when voids, created in the packing material of a column, cause the mobile phase and accompanying solutes to move more rapidly than the average flow velocity through the column. Channeling leads to band broadening. The voids are created by poor packing or by erosion of the packed bed.



The method disclosed by the Hamilton patent does include the "intermediate service" of the present invention. Therefore, the unexpected improvement and effects described above are not disclosed or in any way suggested in the Hamilton patent:

After column 20 has been regenerated the column is rinsed to remove any remaining regenerant. Typically the rinse effluent from column 20 is passed through column 30 to use up any exchangeable regenerant ions in the rinse effluent.

Next, column 10 is back washed to remove any suspended matter filtered from the fluid being treated and other fines and to help to separate the weak and strong resins into distinct layers. Backwashing is carried out at this point because the density differences between strong and weak resins are greater when the resins are in the regenerated form. (Hamilton patent, col. 5, lines 4-15).

The "backwashing" disclosed in the Hamilton patent is carried out in order to separate the weak resins and the strong resins based on their different densities. The "backwashing" disclosed in the Hamilton patent does not include passing liquid through the tower upward from the bottom of the tower as in the present invention. In the prior art, in order to wash the resin, a back wash regenerator and water are typically used (see the attachments hereto). However, the combination of "passing the regenerant solution through the tower downward from the top part of tower" and thereafter "passing water through the tower upward from the bottom of the tower", is not disclosed in the Hamilton patent.

Applicants have discovered a method of regenerating an ion exchange resin that includes repeated application of an aqueous solution of regenerant from the top part of the regeneration tower in a downward direction followed by passing ultra-pure water through the regeneration tower in an upward direction from the bottom of the regeneration tower. The present method prevents channelling and provides an ion exchange resin is more homogeneously regenerated than by using prior art methods.

No combination of the Hamilton patent or the Kunin patent teaches, describes or suggests the method and/or the improvement of the present method. Therefore, the rejection of claims 1 and 2 under 35 U.S.C. § 103(a) should be withdrawn.

Claims 3 and 4 stand rejected under 35 U.S.C. § 103(a) as being obvious over the Hamilton patent in view of the Kunin patent and further in view of U.S. Patent No. 4,652,352 to Saieva et al. (hereinafter referred to as "the Saieva patent"). The Examiner maintains that it would have been obvious to one skilled in the art to subject the ion exchange resin based on the combination of the Hamilton patent and the Kunin patent to multiple regeneration and washing steps in order to ensure that the resins are adequately regenerated and washed and that it would have been obvious to use vinyl chloride in ion exchange resins as disclosed in the Saieva patent. Applicants respectfully disagree.

The Saieva patent discloses a process and apparatus for recovering metals from dilute solutions. In the Saieva patent, the ion exchange resin is used as the means to recover the metals from dilute solution. The Saieva patent discloses a closed loop process and apparatus whereby metals may be recovered from spent electroplating rinse solutions for reuse in the electroplating bath with essentially no generation of waste.

As noted above, no combination of the Hamilton patent and the Kunin patent discloses, teaches or suggests the present method of regenerating an ion exchange resin that includes repeated application of an aqueous solution of regenerant from the top part of the regeneration tower in a downward direction followed by passing ultra-pure water through the regeneration tower in an upward direction from the bottom of the regeneration tower. Further, no combination of the Hamilton patent and the Kunin patent discloses, teaches or suggests the improvement provided by the present method, i.e., preventing channelling and providing an ion exchange resin that is more homogeneously regenerated than obtained by prior art



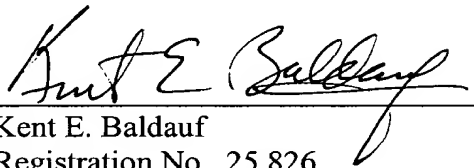
methods. Utilizing the material disclosed in the Saieva patent does not provide any motivation to use the method described above.

Therefore, the rejection of claims 3 and 4 under 35 U.S.C. § 103(a) should be withdrawn.

In view of the foregoing arguments and remarks, reconsideration of the rejections and allowance of claims 1-4 are respectfully requested.

Respectfully submitted,

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# 分析化学ハンドブック

Analytic Chemistry Handbook

分析化学ハンドブック  
編集委員会

編集

朝倉書店

Published by Asakura Shoten

表 3.2 6 M HCl からの MIBK 抽出

分配比 D	金 属 元 素
$D \geq 10^2$	Ga
$10^2 > D \geq 10^1$	Au In Pa Mo
$10^1 > D \geq 10^0$	Re Fe(III) Se Pt Cr
$10^0 > D \geq 10^{-1}$	Tc Cd U(V) Ir Os
$10^{-1} > D \geq 10^{-2}$	Np Zn Ru Nb Cu Hf Zr
$10^{-2} > D$	Rb Sr Pd Mn K Ni Ba Eu Co Lu Tb Ce(III) Sc Th Pm Na Y Ca Cs La

ート抽出が主として金属イオンを対象にしているのに比べ、陰イオンの抽出には不可欠な系である。この点に注目した研究の進展によって、優れたイオン対抽出系が開発される可能性があると考えられる。

これまで述べてきた例に限らず溶媒抽出は、分析化学のみでなく放射化学や工業的規模での分離などに応用できるので、分離の一方法として利用する際には幅が広く、理論と実用とが調和した分野である。

(川本 博・赤岩英夫)

## 参考文献

- 1) 赤岩英夫, 川本 博, 小暮庄司: 分析化学, 28, 498 (1979).
- 2) H. Akaiwa, H. Kawamoto, Y. Yoshimatsu: *Bull. Chem. Soc. Jpn.*, 52, 3718 (1979).
- 3) 赤岩英夫, 川本 博, 冷牟田悦夫: *日化*, 1979, 1716.
- 4) H. Kawamoto, H. Akaiwa: *Anal. Sci.*, 3, 573 (1987).
- 5) Y. Itoh, H. Kawamoto, H. Akaiwa: *Anal. Sci.*, 2, 43 (1986).

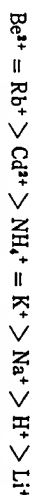
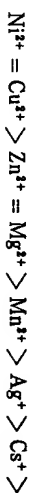
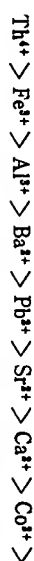
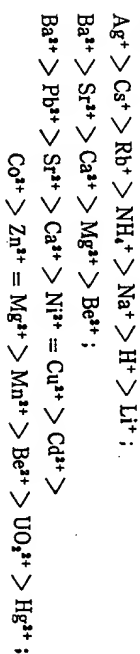
## 3.4 イオン交換

### 3.4.1 イオン交換体

無機分析に用いられるイオン交換体は、通常強酸性または強塩基性イオン交換樹脂が主である。中・弱の交換樹脂や無機イオン交換体、キレート樹脂、酸化還元樹脂などは特殊の目的に使用される。

#### a. 強酸性陽イオン交換樹脂

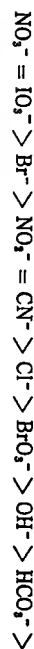
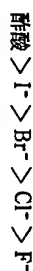
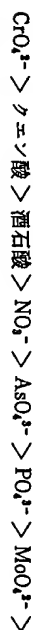
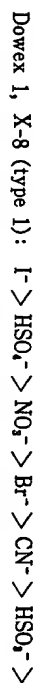
骨格はフェニール縮合樹脂とスチレン-ジビニルベンゼン (DVB) 共重合樹脂で  $-SO_3H$  基をもつ。ベンゼン核に直接ついている  $-SO_3H$  基は、 $-CH_2SO_3H$  基に比べ解離しやすい。この基の選択性は元素の原子番号, イオンの価電とともに増大し, 水和イオン半径の増大につれて減少する。Dowex 50, X-8 について選択性の序列は,



$H^+$  の選択性は低いので、樹脂を H 形に変換するには過剰の強酸を多く用いる必要がある。

#### b. 強塩基性樹脂

市販の樹脂はスチレン-DVB 共重合体を基体とするものが多く、交換基は  $-N^+(CH_3)_3Cl^-$  (type I) または  $-N^+(CH_3)_3C_2H_4OHCl^-$  (type II) が普通である。type I の塩基性は type II より大きい。いずれも交換容量は pH にはほとんど依存しない。陰イオンに対する選択性はイオンの価電とともに増大し、水和イオン半径の増大により減少する。

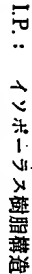
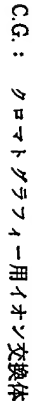
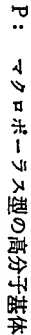
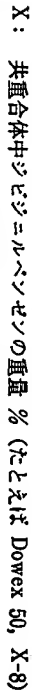


塩基性樹脂は pH 1~13 の範囲のみならず強酸 (12 M HCl) 中でも用いることができる。

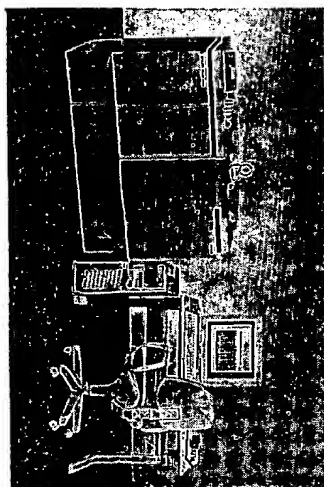
#### c. 樹脂の精製

イオン交換樹脂は通常湿った状態でポリエチレンビンダグまたは瓶に収納されている。セルロースイオン交換体や無機イオン交換体は乾燥状態で供給される。高度に精製された分析用イオン交換樹脂は必ずしも精製の要はないが、イオンの脱着のトリーニングを行わせて使用した方がよい。カラムに水で膨潤させた樹脂を入れ、逆流を含めて十分水で洗う。次に 3 M HCl (HNO<sub>3</sub> は使わない方がよい) を樹脂容積の約 3 倍流し、ついで水洗 (15~20 倍容) したのち、1.5 M NaOH で  $Na^+(OH^-)$  形に変える。再び水洗してアルカリを除く (弱酸・弱塩基樹脂では pH 8 まで)。この操作を 2~3 回反復する。高度の精製を行う場合は、以上につづき、カラムを熱水 ( $H^+$  形樹脂 90~95°C, 陰イオン交換体 60~80°C) で 30 分洗浄し、冷水で洗ったのちメタノール、エタノールまたはアセトンで溶出液が無色になるまで洗う。水で洗ったのち所要の形にかえる。必要により EDTA-2Na, 0.1 M クエン酸やその他の錯形成試薬の溶液により最終精製を行うことがある。樹脂は風乾状態あるいは塩類水溶液の入ったデジケターで保存 (定湿度) する。

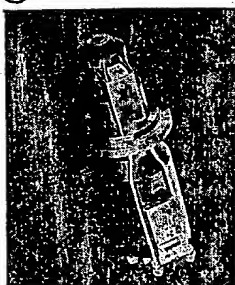
イオン交換体には一般に次のような記号が用いられる。



## 全自動蛍光X線分析装置 PW 2400

Master of the elements  
PW 2400

## 新開発スーパーシャープX線管球(SST)



## ■PW 2400 の特長

- 新開発、7リットラス型スーパーシャープX線管球(SST)の125mA、3kW励起により、超軽元素Beの分析を可能にし、B、C、N、O、Fなどの軽元素の感度が大幅に向上
- SSTとユニークな検出器配置により、光学的距離の短縮(クロスカウンターリング)に成功し、全元素領域の大幅な感度向上を実現
- SSTは特殊ワイヤメント構造で、管球寿命が著しく延び、保証時間も延長
- 微量元素と軽元素のために固定分光器(最大2種類装備可能)を用意し、高感度分析と測定時間の短縮を実現
- ジオメータは $\theta$ および $2\theta$ 軸にシャフト直結式エンコーダ(DOPS)を採用し、 $\theta$ 、 $2\theta$ が独立運動することで角度再現性0.0001°と、高速運動が可能
- 分光結晶もDOPS機構により自動調整
- MFC方式高圧発生器(高周波発振3kW型、安定性0.0005%)により最大電流125mAが得られ、軽元素の励起効率を大幅に改善し、kV、mAは測定中最適値にプログラム交換が可能
- 豊富な分析ソフトウェアは日本語対応で、マルチウインドウ方式
- 各種自動試料交換器と試料作成器で、生産ラインとラボの自動化が可能
- 電話回線を使用した装置のリモート診断が可能で、完全なシステム管理と故障時のダウンタイムの短縮を約束
- 7リットラスX線分析装置の品質標準は、X線装置工場として世界で初めて国際標準化機構から、ISO 9001に認定されたことで実証

## 日本フリップス株式会社

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## Ion Exchange

### Technology Description

Ion exchange is a chemical reaction wherein an ion from solution is exchanged for a similarly charged ion attached to an immobile solid particle (i.e., ion exchange resin). Ion exchange reactions are stoichiometric (i.e., predictable based on chemical relationships) and reversible. The resins are normally contained in vessels referred to as columns. Solutions are passed through the columns and the exchange occurs. Subsequently, when the capacity of the resins is reached, the ions of interest, which are attached to the resin, are removed during a regeneration step where a strong solution containing the ions originally attached to the resin is passed over the bed.

The strategy employed in using this technology is to exchange somewhat harmless ions (e.g., hydrogen and hydroxyl ions), located on the resin, for ions of interest in the solution (e.g., copper). In the most basic sense, ion exchange materials are classified as either cationic or anionic. Cation resins exchange hydrogen ions for positively charged ions such as copper, nickel, and sodium. Anion resins exchange hydroxyl ions for negatively charged ions such as sulfates, chromates, and cyanide.

The basic ion exchange column consists of a resin bed which is retained in the column with inlet and outlet screens, and service and regeneration flow distributors. Piping and valves are required to direct flow and instrumentation is required to control regeneration timing. The systems are typically operated in cycles consisting of the following steps (ref. 3):

1. Service (exhaustion) - Water solution containing ions is passed through the ion exchange column or bed until the exchange sites are exhausted.
2. Backwash - The bed is washed (generally with water) in the reverse direction of the service cycle in order to expand and resettle the resin bed.
3. Regeneration - The exchanger is regenerated by passing a concentrated solution of the ion originally associated with it through the resin bed; usually a strong mineral acid or base.
4. Rinse - Excess regenerant is removed from the exchanger; usually by passing water through it.

The ion exchange process has been commercially available for many years, but early use was primarily for water deionization or softening. Widespread interest in the process for PWB pollution prevention and control is a more recent application that has grown rapidly over the past 10 years.

### PWB Manufacturing Applications

Ion exchange is common in PWB shops for several reasons. Among them are:

- Several PWB rinse water streams are readily compatible with ion exchange. Simple copper-bearing, low-organic streams from micro-etchant, acid dip, and copper electroplating rinses can usually be sent directly to ion exchange with no pretreatment. With carbon filtration and pH control of the incoming stream, additional rinse streams become ion exchange candidates.
- The preponderance of copper as the contaminating metal allows shops to take advantage of the powerful ion exchange/electrowinning combination. Together, these two technologies combine to separate, concentrate and recover copper from rinse streams.
- Ion exchange offers shops the ability to close-loop some rinses and reduce the need for downstream treatment.
- Due to the large number of rinses potentially amenable to ion exchange and to the ability of ion exchange to produce compliant effluent, some shops (particularly small ones) can employ metal-scavenging ion exchange as a primary end-of-pipe system.
- Reducing the quantity of copper entering the waste treatment system greatly reduces the quantity of wastewater treatment sludge generated, which is typically shipped off-site as hazardous waste.

Generally, ion exchange is limited to dilute rinse water streams although scavenging resins can be used to treat more concentrated wastes under certain circumstances. As concentrations increase, ion exchange becomes impractical due to the increasing frequency of regenerations and the declining difference between the concentration of the regenerant which is a constant (typically 5-10 grams/liter) and the concentration of the stream being treated.

Drag-out recovery tanks are used in conjunction with ion exchange systems whenever feasible to reduce the load on the ion exchange system. In operation, the drag-out tanks return the bulk of the plating chemicals directly to the plating bath and an ion exchange unit connected to a subsequent flowing rinse captures only the residual chemicals. The needed size of the ion exchange unit and its regeneration frequency are therefore reduced.

Metal Scavenging Applications. When the sole objective of using ion exchange is to remove metal from a wastestream, a metal scavenging configuration is employed (Exhibit 5-10). This system uses only one type of ion exchange resin, either selective anion or cation, depending on the charge of metal or metal complex being targeted for removal (e.g., a cation-type resin is used for most copper removal applications). Because this system does not have both cation and anion resins, the rinse water will not be fully "deionized" and cannot be reused as rinse water for common rinsing purposes. The primary advantage of metal scavenging is the large capacity (in terms of rinse water treated) vs. a deionizing configuration since only divalent cations are exchanged and common monovalent cations such as sodium and potassium are bumped off the resin and passed. Thus, regeneration cycles are longer, lowering chemical and other operating costs.

Certain PWB wastestreams are commonly treated with the metal scavenging configuration. Most common are copper, tin-lead and gold rinse systems. Various copper rinses are commonly processed with this technology, including etch, microetch, and copper electroplating. Resins are regenerated using sulfuric acid. In the case of tin-lead, ion exchange scavenging is employed to remove lead from rinse water which is then often discharged. Regeneration may be performed on-site with methane sulfonic acid (MSA) or the resin, when exhausted, can be shipped off-site for processing/disposal. Point source ion exchange treatment of tin-lead rinses may be

performed to protect downstream units from lead-bearing streams. Ion exchange may also outperform the primary waste treatment system and this configuration may cost-effectively maintain compliance where lead discharge limits are more stringent than copper limits. Gold rinses are often ion exchanged for the purpose of gold recovery. When exhausted, gold-bearing resin is usually processed offsite to assure efficient recover of the gold.

Deionization. When the objective is to recover metal and recycle rinse water (i.e., closed-loop), a deionization configuration is employed. This configuration uses a combination of cation and anion exchange columns in series to remove all ions from the rinse water (Exhibit 5-11). This strategy may be employed when continuous discharge is impractical due to stringent limits, or where the benefits of water reuse outweigh the cost of installing and operating water recycling ion exchange unit.

A good candidate for deionization is the electroplating copper rinse system. With this application, rinse water containing copper is sent to the cation and anion exchange columns and deionized water is returned as fresh rinse water to the rinse system. The anion regenerant, usually NaOH, can usually be pH treated and discharged. The cation regenerant stream is interesting due to its similarity to the plating bath make-up—sulfuric acid and copper sulfate. While it is possible to return the regenerant to the plating bath thereby closing the loop for most of the process, this is generally not done for two important reasons: (1) the performance of the PWB through-hole plating in various stress tests is quite sensitive to small variations in bath chemistry making additions of regenerant inadvisable and (2) the copper sulfate plating bath is operated at too low of a temperature to create sufficient evaporative headroom for the regenerant additions. The regenerant is an ideal electrowinning candidate and this is the most common treatment option.

Deionization or metal scavenging can be accomplished using "point-of-source" ion exchange as shown in Exhibits 5-10 and 5-11 or using a central system similar to that shown in Exhibit 5-12. With this system, rinses are first processed through a selective resin for cation removal and subsequently through anion and cation resins for complete deionization and then returned to the rinse system (ref. 36).

Process Residuals. The primary residuals from ion exchange recovery processes are the regenerants and backwash solutions. The regenerants are concentrated wastes and the backwash is dilute. Both solutions are either caustic or acidic, depending on the resin type and application. High metal bearing regenerates (typically cation resin) are sometimes reused directly in the bath, further processed to recover the metal (e.g., electrowinning), waste treated or sent to an off-site recovery facility. Low metal bearing regenerants (typically anion resin) and backwash solutions are typically treated on-site. Waste treatment processes generate sludge that is an EPA listed hazardous waste (F006).

The volume of regenerant produced will depend on the regeneration requirement (e.g., lbs of acid per ft<sup>3</sup> of resin) and the concentration of acid used (typically 1 to 5%). The regeneration requirement will depend on the resin type, application (metal or complex being recovered) and the configuration (cocurrent vs counterflow). Typical volumes of regenerant are 20 to 50 gal/ft<sup>3</sup> of resin. The volume of regenerant waste is sometimes reduced by reusing the last portion of the regenerant, which will be less contaminated with metal and contains free acid. Backwash volumes depend mostly on the equipment design and the application. Typically, backwashing generates 25 to 75 gal/ft<sup>3</sup>. The backwash is partly reused by some equipment vendors as make-up water for regenerant, in an effort to reduce the total waste volume generated. Because backwash contains only dilute concentrations of pollutants it is typically not a major concern and is treated on-site and discharged. However, for shops working toward zero discharge, the backwash volume could present a significant problem. Both backwash and regenerant can be processed by evaporation to reduce the volume requiring disposal. However, this increases the capital and operating costs of the system. Also, evaporation of hazardous wastes is sometimes regulated as a RCRA technology and may require a permit to operate.